MATE 316

Spring 2020

Homework # 1

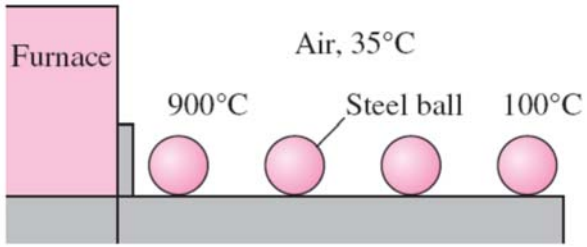
Due February 28th, 2020 (lecture time)

Group submission (up to 3 students per group) is allowed.

Question 1:

Carbon steel balls (ρ = 7870 kg/m^3) 8 mm in diameter are annealed by heating them first to 900°C in a furnace, and then allowing them to cool slowly to 100°C in ambient air at 35°C. If 2500 balls are to be annealed per hour, determine the total rate of heat transfer (in W) from the balls to the ambient air.

For steel C_p = 37.12 + 0.00617 T J/mole.K



Question 2:

A disk 40 cm in diameter and 5 cm thick is to be cast of pure aluminum in an open mold casting process. The melting temperature of aluminum is 660°C and the pouring temperature will be 710°C.

Assume that the amount of aluminum to be heated will be 5% more than what is needed to fill the mold cavity. Compute the amount of heat that must be added to the metal to heat it to the pouring temperature, starting from a room temperature of 25°C.

Given:

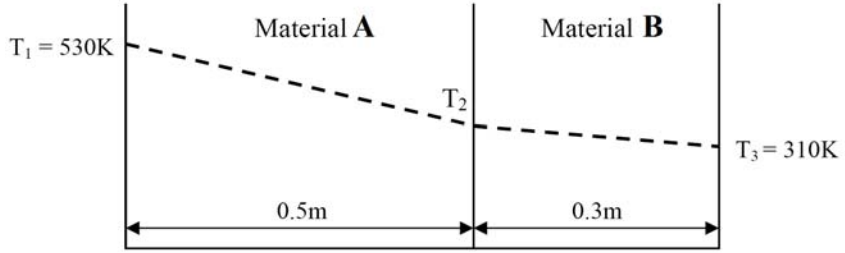
The heat of fusion of Al = 389.3 J/g **ρ = 2.70 g/cm^3**

Heat capacity of solid Al = 1.04 J/g

Heat capacity of liquid Al = 1.18 J/g

Question 3:

Find the thermal conductivity of B if the steady-state heat flux is 12.6 x 10^3 [W/m^2] and the conductivity of A is 52 [W/mK].



Question # 4

The heat flux (q) at the surface of an electric heater is 8000 W/m^2. The heater temperature is 120°C when it is cooled by air at 70°C.

a) What is the average convective heat transfer coefficient (h) ?

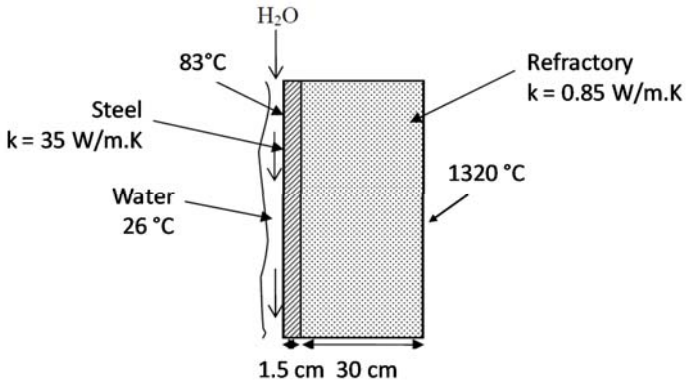
b) What will the heater temperature be if the power is reduced so that q is 2000 W/m^2?

Question 5:

Compute and compare the room temperature thermal diffusivities of aluminum, silver, tungsten and water.

Question #6:

The wall of a blast furnace is water-cooled as shown. Given the inside and outside surface temperatures of 1320°C and 83°C, what is the heat transfer coefficient for the water? The water, itself, is at 26°C. Assume steady-state conditions.



Question #7:

A black thermocouple measures the temperature in a chamber with black walls. If the air around the thermocouple is at 20°C, the walls are at 100°C, and the heat transfer coefficient between the thermocouple and the air is 75 W/m^{2}K, what temperature will the thermocouple read?

Note:
The emissivity is 1 for black bodies.
Stefan–Boltzmann constant (σ) is 5.6704×10^{-8} Wm^{-2}K^{-4}
Assume that the system is at steady state.